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WO 96/28987 A1 WO 94/03235 A1 US 5113853 A

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(54) **Air filtration system for a helmet**

(57) The system, which either includes a helmet or other head covering or is for mounting on such a helmet etc., includes a rear portion 22 and frontal portion 26, at least one air vent 20 for directing air towards the rear portion, channels 24 for directing air from the rear towards the frontal portion and air filters 30 for filtering air passing through the system. A pump may be provided for creating an air flow through the system and the helmet may carry a pivotable, full face visor. The filters may each comprise an electrostatic filter followed by a layer of activated charcoal or carbon cloth.

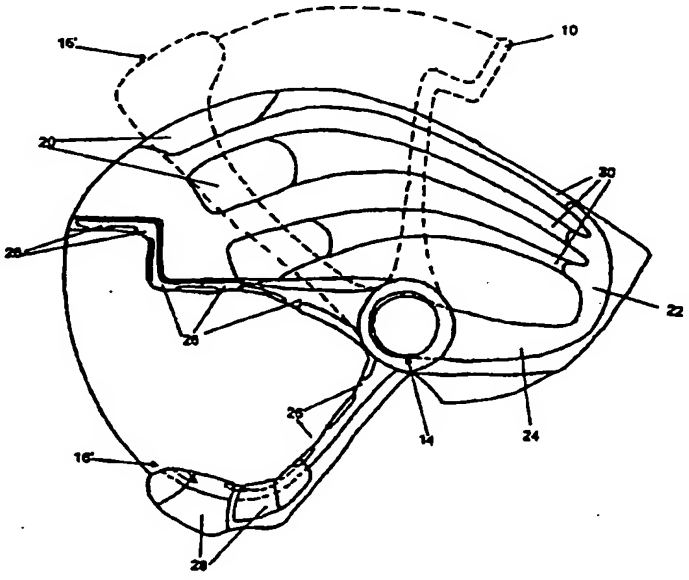

Figure 3

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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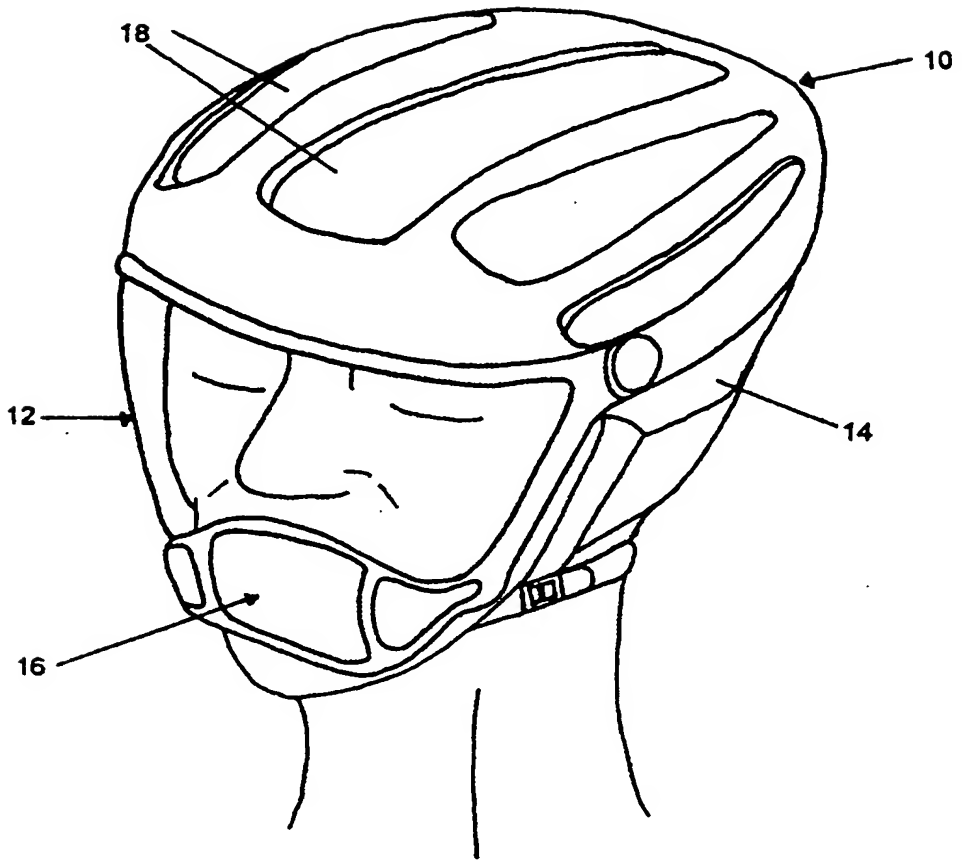

Figure 1

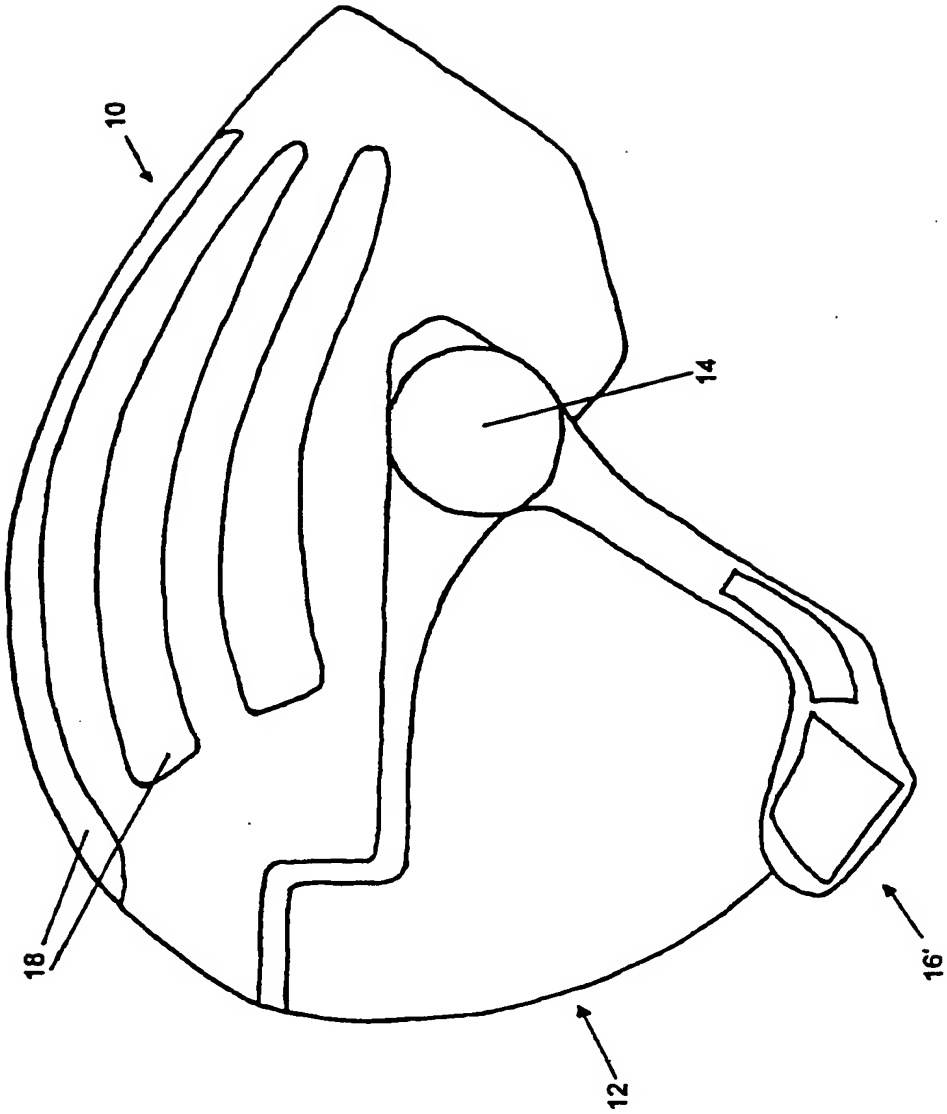

Figure 2

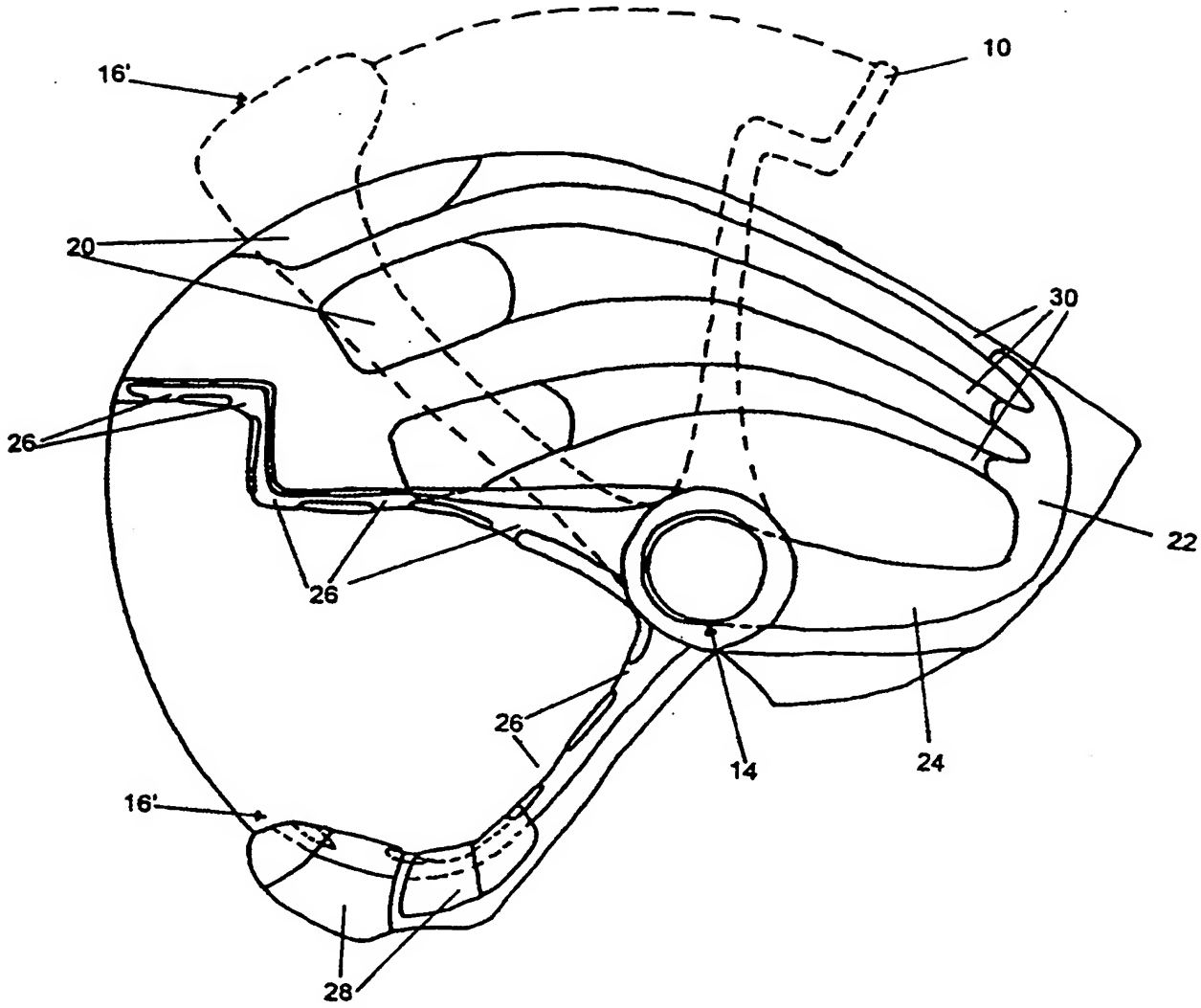

Figure 3

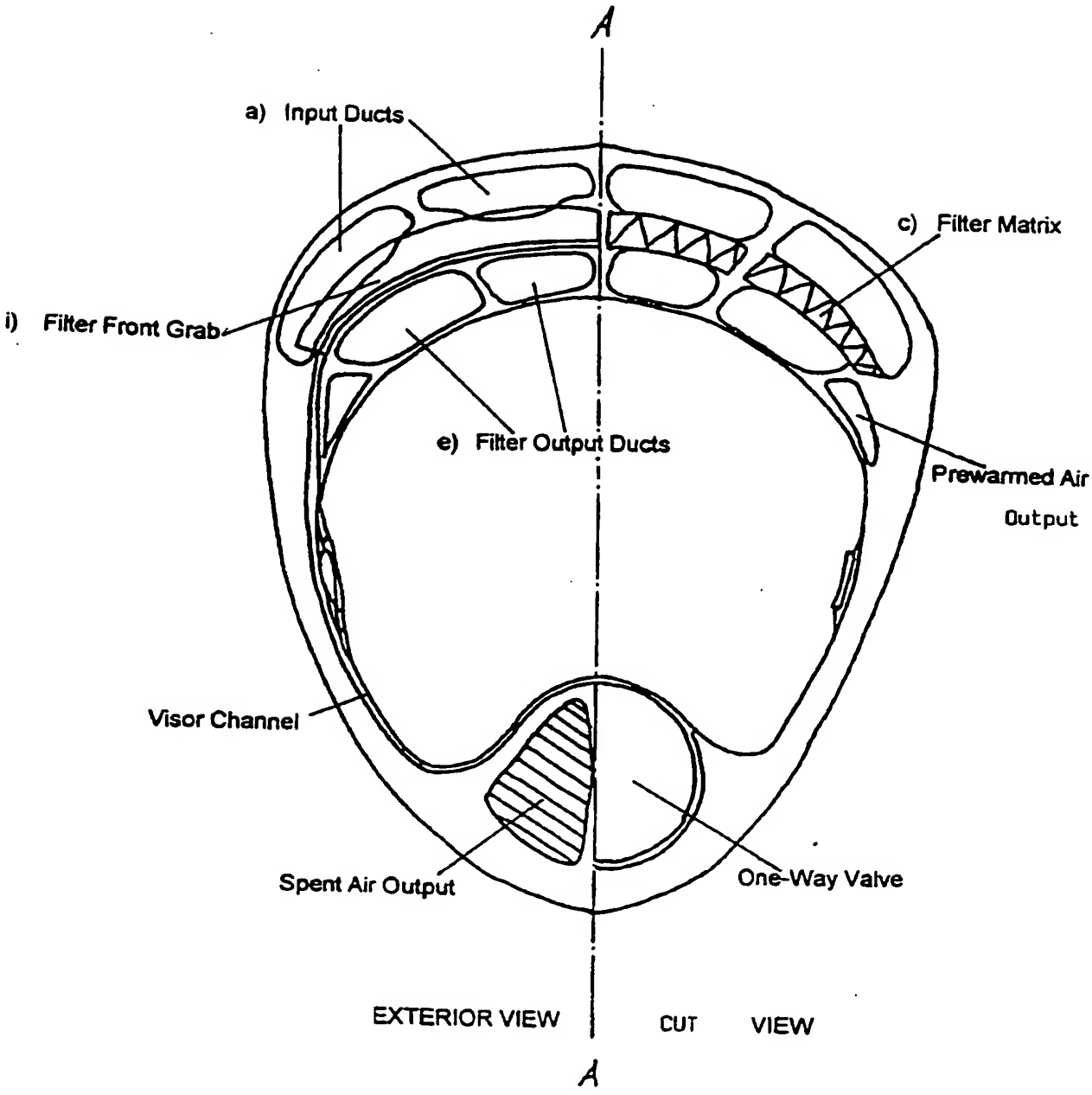
A
a) Input Ducts
c) Filter Matrix
i) Filter Front Grab
e) Filter Output Ducts
Prewarmed Air Output
Visor Channel
Spent Air Output
One-Way Valve
EXTERIOR VIEW
CUT VIEW
A

Figure 4

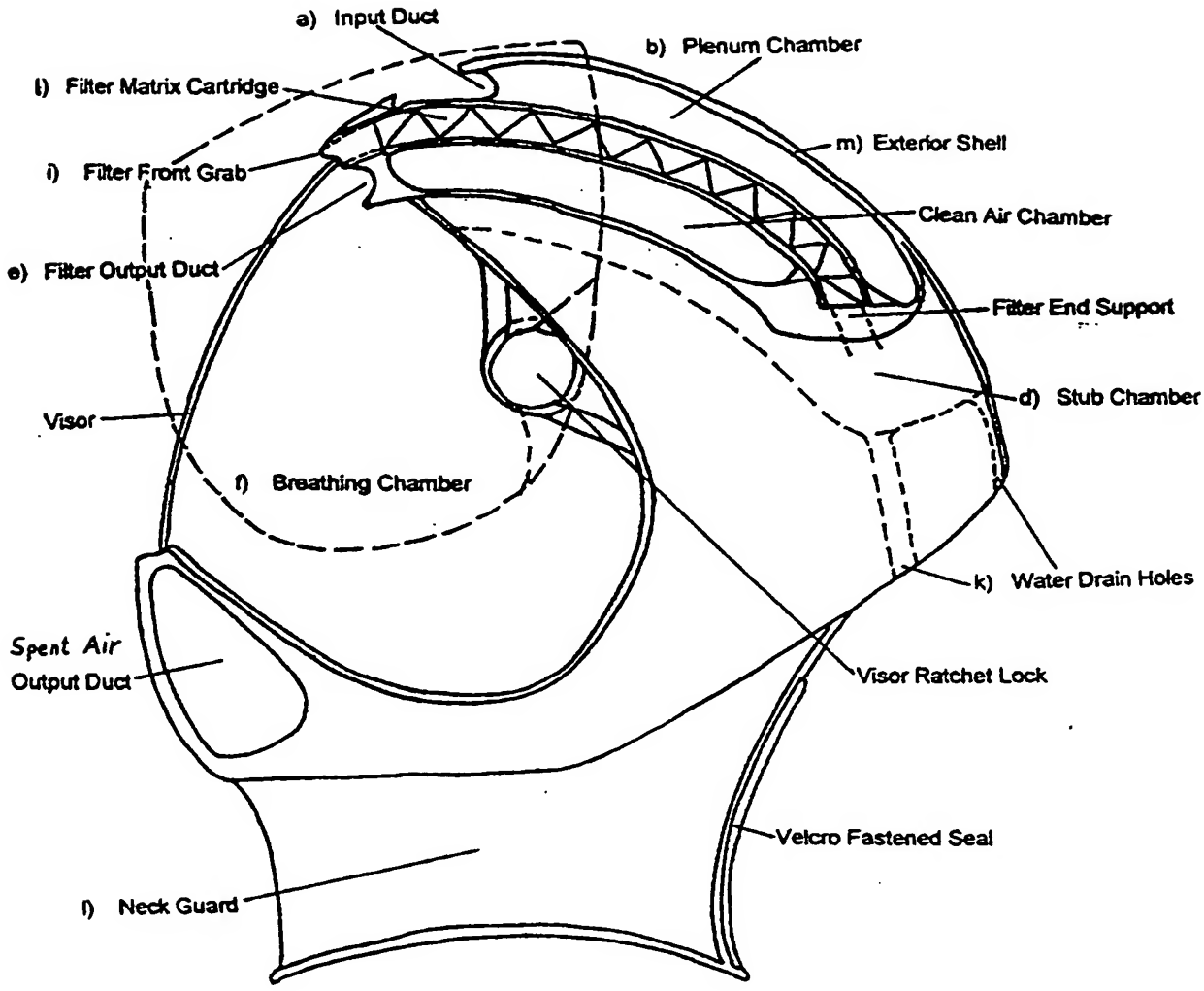
a) Input Duct
b) Plenum Chamber
l) Filter Matrix Cartridge
m) Exterior Shell
i) Filter Front Grab
Clean Air Chamber
e) Filter Output Duct
Filter End Support
d) Stub Chamber
Visor
f) Breathing Chamber
k) Water Drain Holes
Spent Air
Output Duct
Visor Ratchet Lock
Velcro Fastened Seal
j) Neck Guard

Figure 5

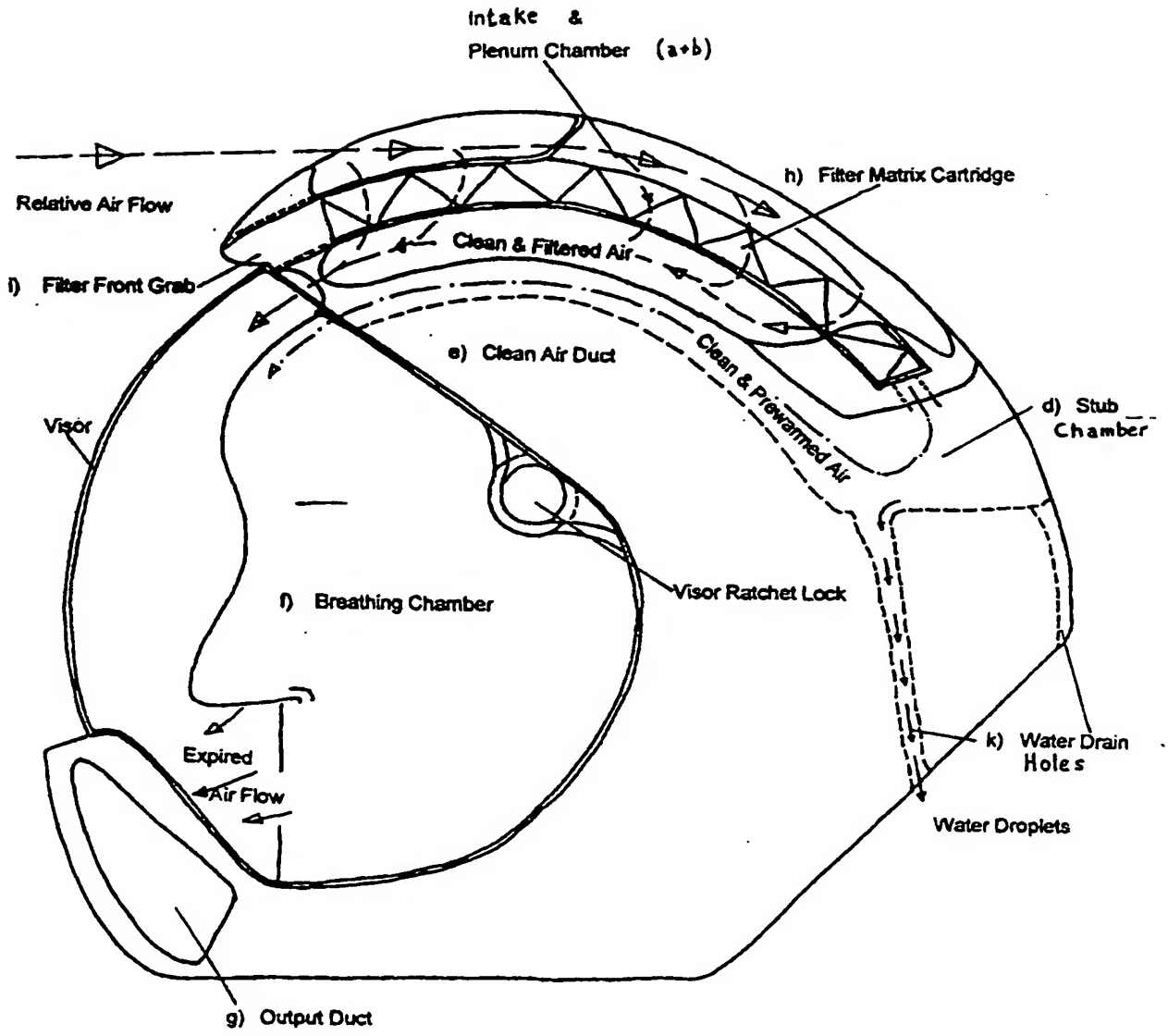
Intake &
Plenum Chamber (a+b)
Relative Air Flow
h) Filter Matrix Cartridge
Clean & Filtered Air
i) Filter Front Grab
e) Clean Air Duct
Clean & Prewarmed Air
d) Stub Chamber
Visor
Visor Ratchet Lock
f) Breathing Chamber
Expired
Air Flow
k) Water Drain Holes
Water Droplets
g) Output Duct

Figure 6

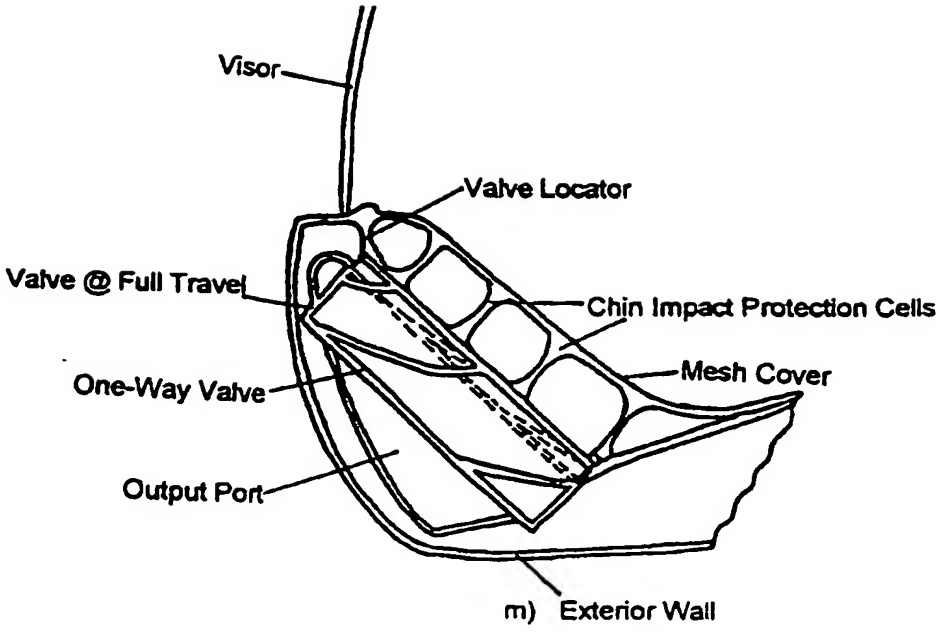
Visor
Valve Locator
Valve @ Full Travel
Chin Impact Protection Cells
Mesh Cover
One-Way Valve
Output Port
m) Exterior Wall

Figure 7

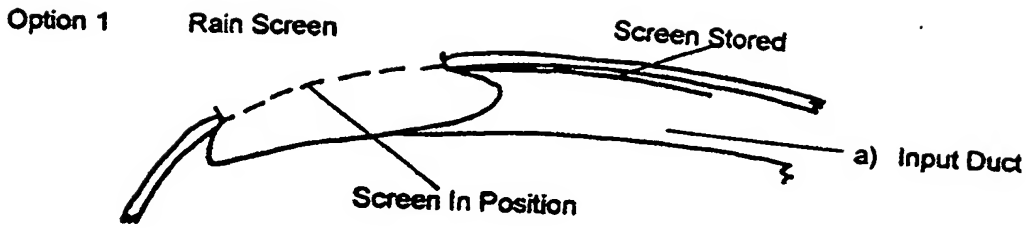

Figure 8

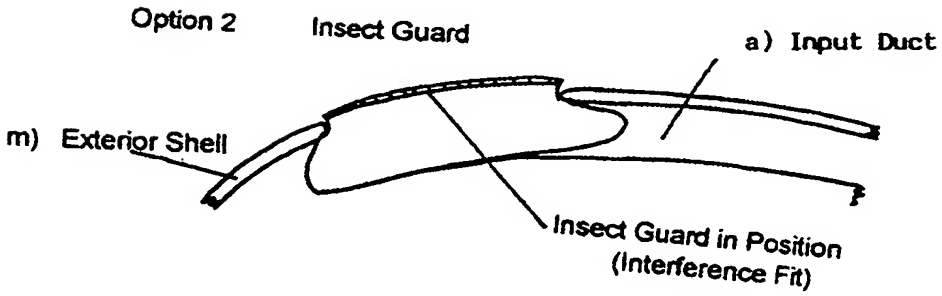

Figure 9

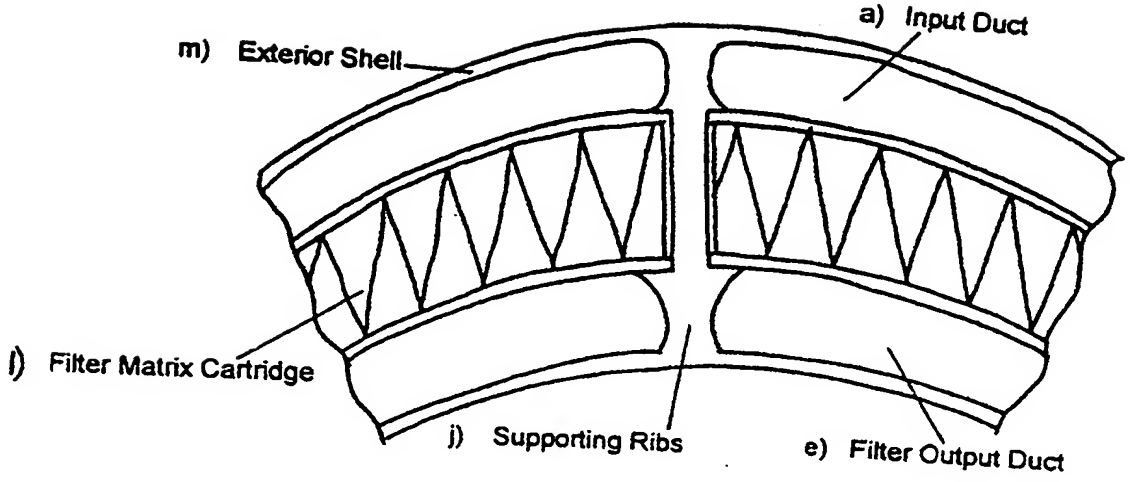
a) Input Duct
m) Exterior Shell
l) Filter Matrix Cartridge
j) Supporting Ribs
e) Filter Output Duct

Figure 10

AIR FILTRATION SYSTEM

The present invention relates to an air filtration system for personal use.

With increases in air pollution, particularly in cities, it has become common for people carrying out physical activities to wear air filtration systems in order to try to reduce the amount of polluted air breathed. The most common filtration system provides a mask which fits over the user's mouth and nose and which is held in place by elasticated or adjustable straps. in use located around the back of the user's head. The mask is either formed of filtering material or includes apertures which are covered with one or more filters. The mask or filter part can normally be cleaned or replaced as required.

US-A-5139017 discloses an alternative filtration system which is coupled to a protective helmet. The helmet has provided at a frontal portion thereof an aperture in which a filter is provided. The aperture couples to a conduit connected to tubing and eventually a mouth-piece through which the user can breathe.

DE-A-4326724 discloses a protective helmet which includes a filter unit located at a frontal portion of the helmet and in place of the normal protective layers. The filter unit includes a plurality of filter members located in elongate housings. Air vents coupling the filters to an internal conduit are provided. The internal conduit has an exit port which is directed to a visor of the helmet. Thus, when the user is travelling in a direction so as to encounter air flow towards the user, air passes through the filter and then through the conduit to the exit port. Filtered air thus reaches the user at the visor area of the helmet.

Commercially available masks have displayed a number of disadvantages including: the accumulation of heat and sweat in the filtration system and thus close to the user: restriction of air flow to the user: poor comfort and sometimes

the need for tight fitting of the system to the user; inability to provide air flow peaks when required by the user, thereby inducing gasping; a feeling of gagging; and aggressive appearance of the filtration system.

The feelings of gagging and gasping sometimes associated with these filtration systems are as a result of inefficient removal of carbon dioxide, which has the effect of increasing levels of carbon dioxide in the blood and thereby possible hyperventilation.

The present invention seeks to provide an improved air filtration system.

According to an aspect of the present invention, there is provided an air filtration system including a helmet including a rear portion and a frontal face portion; at least one air vent operable to direct air towards the rear portion of the helmet; conduit means operable to direct air from the rear portion of the helmet towards the frontal face portion; and air filtering means for filtering air passing to the frontal portion of the helmet.

The term helmet is intended to include a protective helmet and any other head covering.

Preferably, there are provided a plurality of air vents extending from an outer frontal region of the helmet towards the rear portion of the helmet. At the frontal region, the air vents are preferably open and are covered thereafter, thereby to provide channels through which air can pass when an air stream impinges on the frontal region of the helmet in a direction towards the rear portion of the helmet.

The conduit means preferably includes a plurality of ports opening into a facial region of the helmet. The helmet is advantageously provided with a visor to

close the facial region from direct contact with ambient air. The ports may be located in portions of the helmet above the user's eyeline and/or in portions of the helmet below the user's mouth area. In the latter case, the ports are preferably provided in a pivotable member. The member is preferably coupled to the visor for pivotable movement therewith.

The air filtration system may be provided with a pump or similar apparatus for generating a flow of filtered air to the frontal portion of the helmet.

According to another aspect of the present invention, there is provided an air filtration system for coupling to a helmet or other head covering including mounting means including a frontal portion for coupling to a frontal face portion of a head covering and a rearward portion for coupling to a rearward portion of the head covering; at least one air vent so as to receive air directed thereto and to direct air to the rearward portion of the mounting means; conduit means operable to pass air from the air vent from the rearward portion to the frontal portion of the mounting means and air filter means for filtering air passing through the air filtration system.

The present invention can provide a system which does not seal the user's mouth and nose areas to the system but which creates an atmosphere in a chamber close to the face of the user. Comfort can thereby be increased.

Moreover, the design of the air vents and conduit enables a greater amount of air to be passed to the user, thereby reducing problems associated with prior art air filtration systems. The use of a pump can considerably enhance this feature.

As will become apparent below, the design of the air vents and conduit means can ensure that when used with a protective helmet, the operative strength of the helmet is not reduced by the air filtration system.

An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a first embodiment of air filtration system incorporated into a helmet;

Figure 2 is a side elevational view of a second embodiment of air filtration system incorporated into a helmet;

Figure 3 is a cross-sectional view of the helmet shown in Figure 2;

Figure 4 is a front elevational view in partial cross-section of a second embodiment of helmet, without a visor;

Figure 5 is a side elevational view in partial cross-section of the helmet of Figure 4;

Figure 6 is a view similar to that of Figure 5 showing the helmet in use;

Figure 7 is a cross-sectional view of an output duct of the visor of Figures 4 to 6;

Figures 8 and 9 are views of different configurations of entrance aperture for the helmet of Figures 4 to 6 suitable also for the embodiments of Figures 1 to 3; and

Figure 10 is a cross-sectional view of part of an embodiment of filter cartridge showing the nature of a pleated filter material able to increase filtering surface area.

Referring to Figures 1 to 3, the embodiments of air filtration system shown are

incorporated into a helmet 10 of the type typically used by cyclists. The helmet 10 is provided with a visor 12 which covers the entire face region of the user. This visor 12 is pivotable about two pivot points 14 provided either side of the helmet 10.

As can be seen in the Figures, at a lower portion of the visor 12, there is provided a breathing unit 16, 16'. The function of this breathing unit 16, 16' is described in further detail below.

The outer surface of the helmet 10 is provided with a plurality of channels 18 which extend from a frontal portion of the helmet 10 to a rear portion. As will be appreciated from Figure 3, at the front of the channels 18, there are provided apertures 20. At the other end, the channels 18 are coupled to a common conduit 22 within the rear portion of the helmet 10 and extending across the rear of the helmet.

Both sides of the helmet 10, in the embodiments shown, have the same structure.

Coupled to the rear conduit 22 are a pair of side conduits 24 (only one being visible in Figure 3) which extend, in this embodiment, to an area proximate pivot point 14 and thereby to the breathing unit 16, as will be apparent from Figure 3.

The frontal portion of the helmet 10 is provided with a plurality of ports, most of which are coupled to the side conduits 24. In the example shown, there are provided a plurality of ports 26, at a lower front surface of the helmet, that is approximately eye area of the user.

Additional outlet ports 26 are located on the pivotable breathing unit 16, 16'. The pivotable breathing unit is also provided with exit ports 28 through which air can be expelled from the visor region within the helmet.

Within the air channels 18 there are provided air filters 30, which may be of any suitable construction. For example, they may include a region of small particulate filter matter such as PM10 (TM) or HEPA and a region of activated charcoal or carbon cloth.

An air pump (not shown) may be provided for creating an air flow through the channels 18 and into the helmet 10.

In use, when an air stream is created against the frontal region of the helmet, typically during forward motion of the user, such as during cycling and the like, air passes into the apertures 18. The filters 30 filter this air, which then passes to the rear conduit 22. The air pressure produced generates an air flow through the lateral conduits 24 to the outlet ports 26 and hence into the visor region of the helmet. The location of the ports 26 ensures that air does not flow directly into the face of the user. When the user inhales, the air inhaled is the filtered air provided through the ports 26. On exhalation, air passes out of the exit ports 28 into the surrounding environment.

It will be apparent that as a result of air flow produced, the pressure within the visor region of the helmet will normally be higher than environmental pressure, thereby ensuring that the majority of air inhaled by the user is the filtered air rather than any air obtained by back flow through the exit ports 28. In a preferred solution, a suitable one-way valving system could be provided to permit only exit of air through the exit apertures 28. In this way, clear air circulation is possible while stationary, due to the action of the non-return valves.

Since the user is provided with an environment around the entire facial region and is not subjected to a seal around the nose and mouth areas, comfort is substantially improved. There is very little and normally virtually no resistance to air being expelled by the user as a result of the exit ports 28, which

substantially increases the removal of carbon dioxide, heat and moisture created during breathing.

When an air pump is provided, a constant stream of filtered air can be provided to the user irrespective of the movement of the user.

The visor 12 can be pivoted and locked in an upright position, in which case the air filtration system would not operate to the benefit of the user and can be arranged to close off the filter apertures when it is moving. When an air pump is provided, means may be included for disabling the air pump when the visor is in the upright position.

If necessary, there may be provided at the lower surface of the visor 12 a sealing edge to provide a seal at the lower portion of the user's face, thereby to prevent any leakage at all in this area.

It will be apparent from a comparison of Figure 1 with Figures 2 and 3 that the difference between the two embodiments shown is that with that of Figure 1 the breathing unit 16 is somewhat wider and located at the mouth area of the user. This embodiment provides an alternative structure for the breathing unit 16 which may be preferred by some users.

In an alternative embodiment, there is provided an air filtration system which can fit over an existing helmet or other head covering. It is envisaged that this filtration system would have a cap unit in which the channels 18 are provided and which fits over the helmet or other head covering. The cap unit would also include a visor 12 and breathing unit 16 or, in some applications, may provide a breathing unit which can be coupled to an existing visor of the helmet. The cap would also include the conduits 22 and 24 as with the embodiments shown in the Figures.

A specific example of air filtration system of the type shown in Figures 2 and 3 has a helmet with a vacuum formed polyurethane shell provided with high density expanded polystyrene impact-absorbing foam. The helmet includes securing straps, locking clips and adjusting buckles as with conventional helmets. The visor has at the pivot points 14 a geared locking pin system in which each pivot point of the visor 12 has an inner surface with teeth thereon engageable with a toothed gear fixed to the helmet. The visor can be pulled forwards to disengage the teeth of the pivot points from the teeth of the gears, thereby to enable the visor to be pivoted upwardly. Each toothed gear could be of a nature which enables the visor to be locked in any position, when the pivot points are pushed back onto their respective toothed gear.

The breathing unit 16 is provided with lightly sprung valves, preferably made from latex rubber. The air filters 30 are accessible from inside the helmet and comprise a thin particulate matter filter, HEPA or equivalent electrostatic filter capable of removing up to PM10 particulates; followed by a layer of activated charcoal or carbon cloth arranged in such a way as to maximise capacity, surface area air flow and minimise pressure drop.

In another example, a visor 12 is mounted on a 'conventional' bicycle helmet, where within the helmet lies the intricate filtration system comprising an electrostatically charged particle filter or HEPA followed by a large area of activated charcoal or carbon cloth in separate filter packs to be changed as and when necessary. The air would then pass through this and get vented through a venturi chamber 22, 24 back round to the front sides of the helmet where it runs through tubing/ducting in the visor 12 to provide a positive, cool, clean air wall in front of the face via a thin chamber running around the inside of the visor with air holes, providing a multiaxial air supply around the visor.

The visor 12 can be raised back above the face when not in use or during rainy

conditions when the levels of ambient pollution at face height fall. This would protect the filters from the ingress of moisture and prevent complete misting of the visor 12 during extreme conditions. To return for use, the visor 12 is moved back to seal on the face.

Optional customised sealing can be achieved by inflating a thin rubber tube (not shown) located in the inside edge of the visor 12 using a cycle pump. For this option, in order to prevent a feeling of gagging, the larger the dump valves 28 the better and these are preferably located at the bottom of the visor 12 just below the nose. Vapour in the mask can be removed at the same time as air.

The resulting device gives improved filter capacity and area, higher airflow when cycling at speed with a consequential clean airflow across the face providing cooling and anti-fogging. When stationary, the cyclist's natural breathing action would activate a basal airflow due to the action of the non-return valves.

Including a venturi effect chamber 22, 24 into the cavity at the back of a cyclist's helmet 10 increases the speed of the air passing over and through the filters 30 towards the cyclist's face, improving cooling and reducing fogging.

The visor 12 directs the air flow to the respiratory passages, and the ports 28 just below the mouth/nose area allow one-way escape of the exhaled air to prevent 'gagging'.

Cyclists who wear helmets are protecting their heads - but not much more. A study by the American Academy of Paediatrics found that, among victims of cycling accidents brought into casualty wards, helmets decreased the risk of injury in the forehead to nose area by 65%, but did nothing to prevent injury to the rest of the face. The visor 12 would help to reduce the occurrence of injury to the lower face.

Of the many advantages that the described embodiment can provide, those of note include the following:

1) the visor is kept clear of misting by a constant stream of air at ambient temperature;
2) the face of the user is 'bathed' in air from all directions, thus helping with prevention of sweat forming;
3) clean air is supplied to the user without any material contact or pressure to the nose/mouth region;
4) the exhaust valves 28 are located at the point of use, thereby effectively removing the gagging problem all together;
5) the helmet 10 functions as an air filtration unit, a conventional helmet and offers frontal impact protection; and
6) the overall design is of a robust nature and is designed for easy disassembly to allow for cleaning, servicing and recharging.

The device could be modular, in that elements like the filter and visor may be replaceable, but the basic helmet would last throughout its useful life. There could also be a D.I.Y. kit to allow the attachment and enhancement of standard cycling helmets.

Another embodiment is shown with reference to Figures 5 to 10.

This embodiment, as with those of Figures 1 to 3,

is intended to supply the wearer with pre-filtered air while offering protection against impacts, dependant upon the nature of the application; whether it is a 'Low-Speed' (Cyclist) or 'High Speed' (Motorcyclist and Racing Drivers) application.

Ambient Air enters through the Input Duct (a) into the Plenum Chamber (b); this is enabled by the forward motion of the wearer utilising the relative air flow. The air, having a relative velocity resulting in a partial pressure, is forced through the filter matrix (c). The Shape of the Plenum chamber is such that the air flow is turned perpendicularly into the filter matrix. A percentage of the filtered air flows parallel through the filter matrix emerging at the Stub Chamber (d). This Stub Chamber offers the opportunity for

- Force assisted ventilation, when the user is stationary, or under extreme operating conditions, through the optional inclusion of a fan.
- Pre-warming of the Air through convection of body heat in cold conditions prior to delivery for consumption.
- Removal of accumulated moisture via Stub Chamber Water Drain Holes (k).

The air emerges from the filter matrix into the Filter Output Duct (e). The air is turned through 90 degrees and is exited, at velocity, expanding into the facial cavity. The filtered preheated air drawn from the Stub Chamber enters the Breathing Chamber (f) and mixes with the ambient post-filtered air prior to consumption.

The air is then consumed by the user and exhaled. The Output Port (g) is located in front of the nose and mouth region. The Output Port contains a one-way valve allowing the expired air to exit from the breathing chamber (figure 7), as a result of the

internal partial pressure and exhalation pressure combined acting upon the surface of the one way valve

In order to ensure the operation of the helmet, ample supple sealing , Neck Guard (l), would be provided between the lower helmet base, enabling some protection to the lower jaw region, throat and neck. To allow for personalisation of the seal of this guard a velcro fastener is situtated to the rear of the neck guard.

When the user is stationary (ie: no relative air velocity) there is a subsidiary flow generated across the filters which will provide the wearer with sufficient filtered air to supply the user's 'at rest' requirements, supplemented by inclusion of a forced air ventilation from the Stub Chamber.

To prevent the ingress of rain and insects, protection for the filter is provided by two options:

1. Rain Screen Door, this allows the area of exposed filter to be reduced by closing of the sliding screen (figure 8). When the helmet is used for high speed applications, this screen can be adjusted by the user to offer a comfortable airflow through the helmet
2. Insect Guard Mesh; protection against the intrusion of flying insects into the helmets inner cavities is provided by this interference fit mesh guards (figure9). These can be removed and refitted following cleaning.

Additional protection of the filter during heavy rain conditions can be achieved by moving frontwards and rotating the visor to cover the filter input duct. Primary research suggests that the user would not be affected by the lack of filtered air during such conditions as airbourne pollutants tend to be 'washed' to ground level.

Once the filters are spent, the user is able to renew them by replacement filter cartridges (h). This is enabled by removal of the Filter Front Grab (i) (figure5) and the filters are simply slid in between the Supporting Ribs (j). As one can see from figure10 'View through Filter Matrix Cartridge', the filtering effect offered by the filter

therefore increasing the filter's available surface area. (In practice, the pleats are closer together than the one's illustrated)

Impact protection is supplied through selecting of appropriate materials. For the Helmet Body Exterior Shell (m), materials such as Kevlar, Carbon Fibre, Carbon Fibre/Polymer (CFRP) Laminates and derivatives. ABS, Polystyrene (SAN/ Glass Fibres and Carbon Fibres/Laminates) and expanded foam derivatives; Polycarbonate Foam and Foamed Polymer derivatives ultimate choice being dependant upon envisaged use.

For Lighter applications and use within internal areas of the helmet bodies providing impact energy absorption properties, the expanded foam group of materials would be suitable.

The visor could comprise such materials as polycarbonate laminates, eg: perspex and plexiglass. From 2mm thickness would provide ample direct impact protection to the face of the user for low speed applications However for higher speed applications, the use of kevlar, polycarbonated carbon fibre and its derivatives, glass fibre, laminates as well as armoured glass and its derivatives would be suitable materials

CLAIMS

1. An air filtration system including a helmet including a rear portion and a frontal face portion; at least one air vent operable to direct air towards the rear portion of the helmet; conduit means operable to direct air from the rear portion of the helmet towards the frontal face portion; and air filtering means for filtering air passing to the frontal portion of the helmet.

2. A system according to claim 1, including a plurality of air vents extending from an outer frontal region of the helmet towards the rear portion of the helmet.

3. A system according to claim 2, wherein, at the frontal region, the air vents are preferably open and are covered thereafter, thereby to provide channels through which air can pass when an air stream impinges on the frontal region of the helmet in a direction towards the rear portion of the helmet.

4. A system according to claim 1, 2 or 3, wherein the conduit means preferably includes a plurality of ports opening into a facial region of the helmet.

5. A system according to any preceding claim, including a visor to close the facial region from direct contact with ambient air.

6. A system according to claim 5, wherein the port or ports are located in portions of the helmet above the user's eyeline and/or in portions of the helmet below the user's mouth area.

7. A system according to any preceding claim, wherein the air filtration system is provided with apparatus for generating a flow of filtered air to the frontal portion of the helmet.

8. An air filtration system for coupling to a helmet or other head covering including mounting means including a frontal portion for coupling to a frontal face portion of a head covering and a rearward portion for coupling to a rearward portion of the head covering: at least one air vent so as to receive air directed thereto and to direct air to the rearward portion of the mounting means: conduit means operable to pass air from the air vent from the rearward portion to the frontal portion of the mounting means and air filter means for filtering air passing through the air filtration system.